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Automate immunity tests with Excel

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Immunity tests
Download instructions for spreadsheet

To prove that an electronic product is immune to radiated emissions from sources such as cell phones, amateur radios, and broadcast transmitters, you must perform regulatory compliance tests in accordance with IEC 61000-4-3 (Ref. 1). Because this standard requires you to make multiple measurements, you'll simplify the procedure if you automate your test equipment.

At Hewlett-Packard's Roseville test facility, we've developed an application that uses an Excel spreadsheet and Visual Basic for Applications (VBA) to automate our tests. You can download the application for your own use. We developed the application to control the equipment in our lab, so you'll have to modify the VBA code to control your test equipment. See download instructions , below.

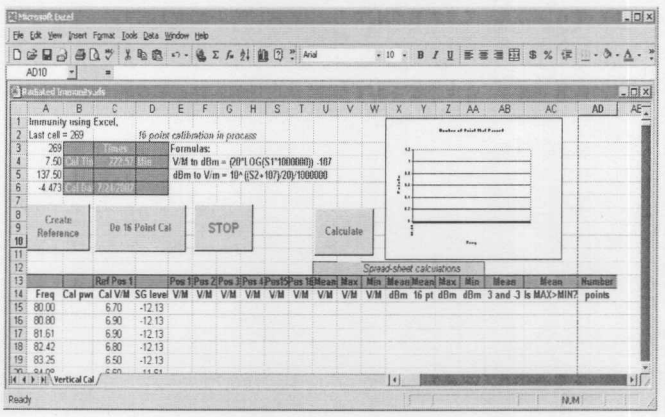
"Immunity tests" describes the setup specified in IEC 61000-4-3. Before you can perform a radiated-immunity test in a semianechoic or full-anechoic chamber, you must calibrate the test site to ensure that the field strength inside the chamber meets IEC 61000-4-3's 1-V/m, 3-V/m, or 10-V/m requirements. The standard also specifies that the E-M field meet uniformity requirements within a vertical plane that's at least 1 m and preferably 3 m from the antenna—the distances from the antenna to the EUT. You measure the field's uniformity within a vertical grid of 16 measurement points, 0.5 m apart, which totals 1.5 m^2 in size.

You need to measure the field strength at all 16 points in the grid for both horizontal and vertical antenna positions at each of the 260 test frequencies. That's over 8300 measurements. You must calculate the mean of the field-strength measurements from the 16 measurements at each frequency. You can get valid results if at least 12 measurements fall within a 6-dB range, so you are permitted to discard up to four measurements that fall farthest from the mean for each frequency. The Excel download has a sheet (**Figure 1**) that will control your test equipment and store the calibration measurements by adjusting a signal generator's output and measuring the field strength. Other sheets will perform calculations, verify the test results, and run the immunity tests.

Note that the field-strength measurements use volts/meter units, but the acceptable range for the measurements is specified in decibels. Therefore, you must convert your measurements. The spreadsheet will do that for you, too.

Using the spreadsheet

When you click on the "Create Reference" button, you'll activate a VBA routine that sets the signal generator's frequency to 80 MHz and measures the field strength at one grid location (reference point). The routine then adjusts the signal generator's amplitude to -20 dBm, which corresponds to 22,360 µV/m on the field-strength meter. The system increases the signal generator's amplitude until the field-strength meter reads 6 V/m. I chose 6 V/m in case other points in the grid have lower field strengths. That level ensures you that no field's strength gets too small to measure. Later, the application will adjust field strength to meet requirements for IEC 61000-4-3.



With the reference location and field strength recorded, you can now take data on all 16 points, rerunning the measurements on the reference point to check repeatability. Clicking on the "Do 16 Point Cal" button prompts you to move the field probe to each point in the grid until you've made measurements at all 16 locations, after which the data portion of the sheet resembles the one in **Figure 2**.

Figure 1 Clicking on the "Create Reference" button lets you set field-strength reference points for calibrating the test equipment prior to an immunity test. (click here to view enlarged image)

With the probe at each location, the application takes field-strength measurements across the entire frequency range. It saves the measurements (in V/m) in columns E through T. From the data, the application calculates the mean of the 16 points (column U), the maximum values (column V), and the minimum values (column W) for each frequency. Next, the application converts each of the 16 measurement points to dBm through the following equation and displays their mean values in column Y (Ref. 2):

Field strength in dBm = 20 * log (*field strength in volts per meter* * 10^6) – 107

IEC 61000-4-3 allows you to remove up to four of the 16 field-strength measurements before you calculate field uniformity. The application removes the measurements that fall more than 3 dB from the 16-point mean by marking them with an asterisk. To aid in the calculations, the application checks to see if the maximum value lies farther from the mean than the minimum value. If so, it sets the cell in column AC to "True." If not, it sets the cell to "False." The state of cells in this column tells the application where to start eliminating values from the calculations. The application then calculates the mean in dBm for the remaining points in the grid and places the values for each frequency in column X and then finds those that fall within ±3 dB of each mean value.

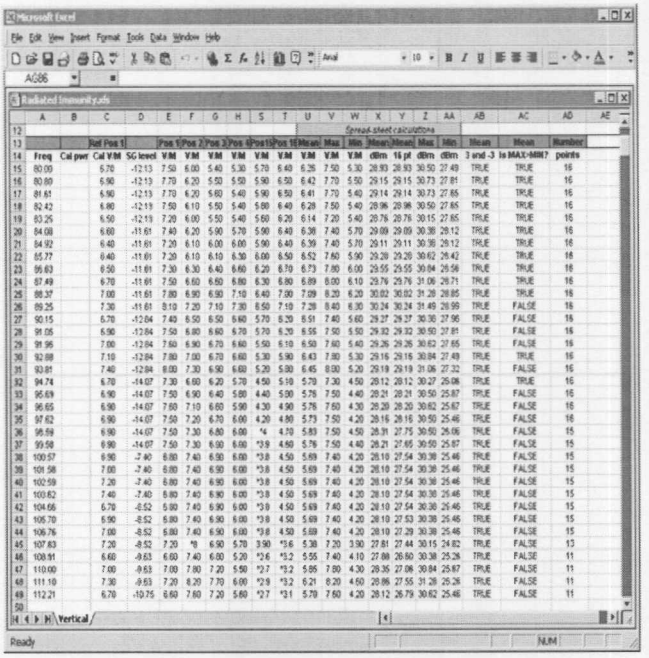


Figure 2 After collecting the data from 16 measurement points, the spreadsheet application calculates the mean and determines which measurements to discard. (click here to view enlarged image)

The value in column X may differ from that in column Y if fewer then 16 points fall within the 6-dB range. In rows 15 through 35, however, they're equal. In the other rows, the values of columns X and Y usually differ because fewer than 16 points fall within the ±3 dB range, so you get a slightly different mean value. If the field uniformity fails to meet IEC 61000-4-3 requirements, then your test will be invalid. When that occurs, you can try moving the antenna slightly or you can add absorbers to your chamber.

Once you verify that at all frequencies, and the field strengths for at least 12 points fall within ±3 dB of the mean (column X), you need to adjust the signal generator's output level until the lowest of the 12 field strengths equals the value of the desired test level (1 V/m, 3 V/m, or 10 V/m). A sheet called "3 V_M Verification" contains VBA code that calculates the amplitude of the signal generator for 3 V/m at each frequency. The application also contains pages for the other field-strength levels.

After you find the proper signal level for each frequency, you can use another sheet (not shown) to verify that nothing has changed before you remove the field probe and place the EUT into the chamber. This additional sheet (Vertical Test verification) lets you measure the field strength and compare it against the calibration measurements. If the verification indicates that fewer than 12 points fall within the required 6-dB field-strength range, you must recalibrate the test site. Fortunately, if you mark the floor locations of the antenna and reference probe position and always use those locations, you shouldn't have to perform the calibration measurements more than once a year, regardless of how many products you test.

If the verification sheet indicates that the field strength is within tolerance, then you're ready to run the immunity test. You can use two more Excel sheets to run the tests. The sheets, one each for horizontal and vertical antenna polarizations, set the field-strength levels at each test frequency. Run the EUT in a mode that you think makes it most

susceptible to radiated emissions. Observe the EUT's performance. If it operates properly at all frequencies, then it passes the test. If not, you must find where the test signal is penetrating the EUT or its cables and make design changes.

Author Information

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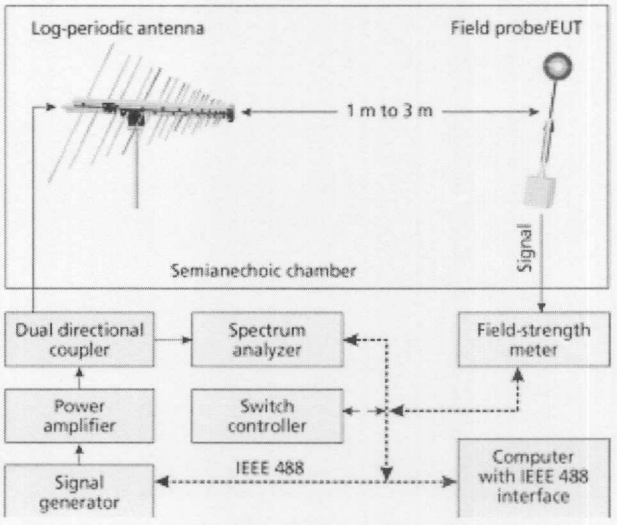
References

1. IEC 61000-4-3 (2002-03) *Electromagnetic compatibility (EMC) - Part 3: Testing and measurement techniques - Radiated, radio frequency, electromagnetic field immunity test.* International Electrotechnical Commission, Geneva, Switzerland. www.iec.ch. (This standard has been adopted, or "Harmonized," by the European Union as EN 61000-4-3.)
2. "Conversion of Signal Levels from mW to mV in a 50V System," EMC Test Systems, Cedar Park, TX. www.emctest.com/pdf/Ant11.pdf, p. 3, item 2.

Immunity tests

IEC 61000-4-3 requires you to subject your equipment under test (EUT) to specified E-M fields at frequencies from 80 MHz to 1000 MHz in approximately 260 frequency steps. The field strength must meet a power specification and a tolerance over a specified area around the EUT. To run the test, you need an RF amplifier, an RF signal generator, a switch controller, and a spectrum analyzer or EMI receiver. You also ne ed a field-strength meter to measure E-M field strength. You must perform the tests in a semianechoic or full-anechoic chamber to avoid possible physical harm to people and to avoid damaging your test equipment.

The **figure** provides an overview of the test setup. A computer with an IEEE 488 interface controls the signal generator, spectrum analyzer, field-strength meter, and switch controller. All test equipment except the transmitting antenna and a field-strength probe reside outside the chamber. You need the field-strength probe to calibrate the test site. Following calibration, remove the probe from the chamber and place the EUT inside.



An antenna and a field probe reside in a semianechoic chamber for calibrating the test field. Test equipment sits outside the chamber, and the EUT replaces the field probe for the test.

Download instructions for spreadsheet

To download the radiated immunity spreadsheet, click on the link below. The zip file contains an 804-kbyte Excel spreadsheet that includes macros that you need to enable.

To run the macros in the spreadsheet, you need to install the Standard Instrument Control Library (SICL) from Agilent Technologies. Without SICL, you'll get an error message telling that the software can't find vbsicl.dll when you click on any of

the buttons. If you use an IEEE 488 interface card from another company such as National Instruments, then you'll have to modify the code to identify the correct DLL.

RadiatedImmunity.zip

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Excel Spreadsheet Figure 1